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Learning objects in high school mathematics classrooms: Implementation and evaluation

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ABSTRACTS

Learning Objects (LOs) within their new features, give new opportunities to learners and educators. LO based learning environments are mostly used within web environments, especially through distance education. This study presents an application about the use of LOs in a real classroom environment. In this application, a Learning Object Repository (LOR) relevant to secondary school mathematics curricula has been prepared and published on the web. The research sample consists of thirty students from a high school at 9th grade. In order to answer the research questions about the implementation of LOs for mathematics teaching in a high school classroom, qualitative and quantitative data were obtained both from the teacher and students participated in the study. The analysis of the data illustrated that students were easily able to follow the instructions of LOs and practise activities within LOs. The attitudes and approaches of students were generally positive. In despite of inconveniency with the teacher's familiar instructional practices, she also expressed her positive opinions about the learning and motivational effects of LOs. These findings support the idea that the use of LOs can be an effective learning tool in high school mathematics classrooms.

1. Introduction

The role of instructional technology in mathematics education specified by NCTM as technology is an essential tool for teaching and learning mathematics enhancing student's learning (NCTM, 2000). As opposed to the idea of learning from technology, this is a new approach to learning with technology. Some research reports have shown that the use of instructional technologies in the classroom improves teaching and learning (Baki & Güveli, 2008; Jonassen, Peck, & Wilson, 1999; Noss & Hoyles, 1996; Wenglinsky, 1998). This implies that designing appropriate educational activities and using them in an educational context can support student's learning. This kind of educational support is generally called scaffolding as Vygostky's term. This approach suggests helping students bring them up to a higher level of understanding. It is shown in many research studies that web can be used as a supporting tool and by applying web based material; students may reach higher levels of understanding (Baki & Güveli, 2008).

Web is a large-scale service where information is stored in digital format and retrieved over networks and facilitates transmission of the information through internet (Baki & Güveli, 2008). In recent years; learning objects as a new information transmission unit has become to be used on web. Learning objects (LOs) are small in size, reusable digital resources that can be used with a web browser support. A short and explanatory definition suggested for LOs as interactive web based tools designed to enhance, amplify and guide learning (Kay & Knaack, 2007). Polsani (2003) proposes an expanded definition about the LOs: "independent and self standing learning content units predisposed to reuse in multiple instructional context. Opposed to traditional instructional media which can only be used in one place at a time", LOs can be reused in different contents. Reusability feature is based on the object-oriented paradigm of computer science, which is the main difference between LOs and classic web tools. LOs may be in the form of text, video, audio, graphics or multimedia. Teachers or instructional designers need an environment to manage, store and organize the LOs that are known as Learning Object Repository (LOR). A LOR may simply be thought as learning objects hosting area. LORs also help teachers or instructional designers create new courses on web that enable the applicability and reusability of LOs (Jenneth, Hunter, Teixeira, Rankin, & Katz, 2002). Managing LOs is generally realized in a structured

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way as search operations in LORs. In order to create search operations, metadata that means "data about data" is used within LOs. Metadata has descriptive information about LOs for finding, managing, using and reusing them more effectively. Perhaps the main distinguishing feature of LO from other tools is their ready availability through web based repositories, collections that can be searched with standardized metadata (Li, Nesbit, & Richards, 2006).

There is supporting evidence that LOs are more useful for students when they are used to illustrate complex concepts and provide practice leading to content mastery (Haughey & Muirhead, 2005). LOs can be designed to support exploration and investigation of mathematical ideas and relations, and help conceptual understanding. Students with different learning needs may also benefit from LOs such as studying new topics, reviewing previous topic, making homework or projects. LOs can also help teachers to introduce new topics or concepts that are explained more difficultly through traditional teaching methods by providing more extended activities for students.

There are many studies that show the benefits of LOs in teaching or learning especially for higher education (Santally & Alain, 2006; Schoner, Buzza, Harrigan, & Strampel, 2005). However few little studies have been made in high school classrooms (Bradley & Boyle, 2004). Hence, it is important to use LOs in high schools to determine their influence on students. In addition, when it is specified to mathematics teaching, the new role of the teacher who makes the students work on mathematical tasks in such environments is determined. The goal of this study is to examine the use of learning objects in high school mathematics classrooms. This includes designing a LOR about mathematics curricula, planning to apply LOs in the classroom and evaluating the benefits of LOs.

The key research questions can be summarized as;

- How did the students use the LOR?
- How did the students evaluate the use of LOs?
- What were students' attitudes and views towards LOR?
- How and for what purpose should the teacher use LOs?

2. Designing of LOs

Wiley (2000) suggests that if the goal facilitates learning with LOs, the instructional design strategies must have main role in use of LOs. Hence, a specific instructional design model is used in this study. The model is focused specifically on creating LOs. This model is a modified version of ADDIE model for LOs and suggests that teachers need to think how the LOs they create might be reused in other environments (Barritt & Alderman, 2004). (Fig. 1)

A schematic explanation of the standards and approaches of content development for LO can be given as below: (Fig. 2)

The phases of the system have been defined briefly as following:

2.1. Object management system

Object Management System, is a kind of web-based environment consisting of the system to work with object repository that is going to be used for determining course materials while associating the objects and these materials.

2.2. Metadata registration environment

One of the important functions of LORs is to categorize and search the LOs. It is an important step to determine the metadata environment. Hence, what is preferred is the most common and generally accepted one, IEEE LOM standards.

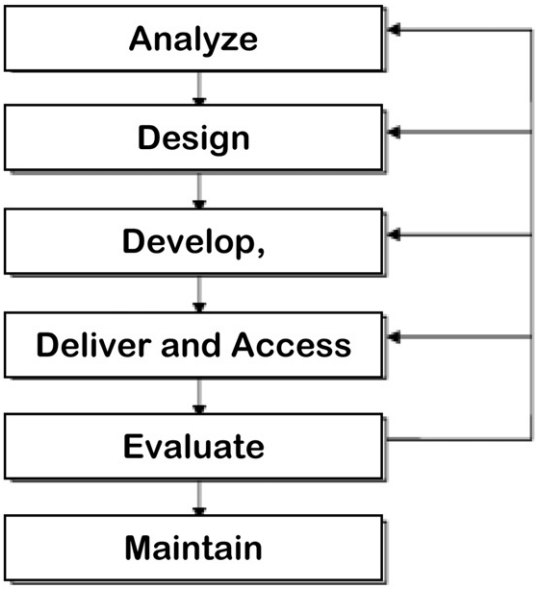

Fig. 1. Expanded Addie Model of LO based instruction design.

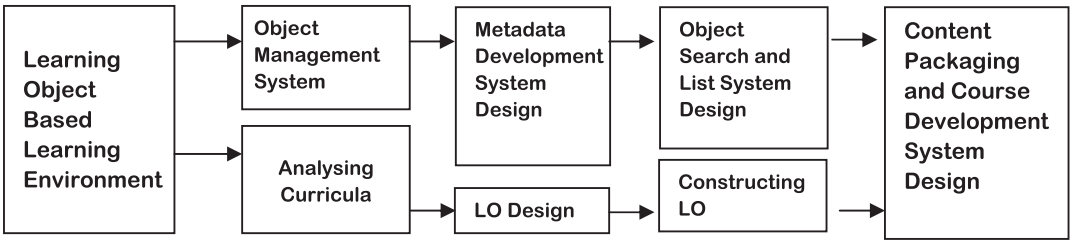

Fig. 2. Content packaging and course development design phases.

2.3. Object repository

A Learning Object Repository is constituted of the components providing a search via object management system depending on the segments storing the objects and metadata information of objects. So, there appeared such a kind of design as below by examining the necessary components to form an object repository presented for the users. The objects have been produced with java and action script codes.

Fig. 3 shows a piece of LOR which the two sample objects are listed. Each object has the main features at the right side of the object image (language (1), keys (2), definition (3), course (4), learning domain (5), sub-learning domain (6)). Also each object is listed in the page including observation, download, evaluation, reading comments and metadata characteristics which are shown as icons under the object image. The meanings of icons are shown under the first object on Fig. 3. These features are useful for gathering data about object, evaluating it and also downloading the object.

To be able to find the searched object in a short time is one of the most significant features of object repository. In order to use "search function" either with the object solely or a part of content development system, the search function includes general characteristics, technical characteristics, educational characteristics, and in accordance with the first letter options. Besides, the function in the system 'extended search' is also a significant function of the system. The system provides search on metadata structure, the key words, or definitions by stating the searched object as a word or word phrase. Designing the object in the form of applet and action script has provided the great item, interaction for scaffolding. In addition, in order to increase the usage of environment, every scenarios and directions have been given in details. Object repository consisting of LOs which are mostly convenient for 9th year mathematics program has been broadcasted on the website of "www.ogrenmenesneleri.org".

3. Process

Study was conducted during spring term of 2007–2008 academic years at a high school in Trabzon. LOs in the applied program include, drill and practice, problem solving, decision making and concept teaching activities. Before application, the use of LOs and LOR is introduced to teacher and students. Then below schedule was applied during 7 weeks with 30 students at 9th grade. (Table 1)

Thus, students had approximately 14 h of computer lab for 2 h per week. The students practiced with LO based learning environment about the topic through 9th grade mathematics curriculum.

In Fig. 4, there are two samples of used LOs. The header of the first one is "Exponents and Square Roots" and it has an activity about finding the approximate exponents or roots by calculating the area of a selected grid. The second one is a part of the object named as "Integers". It consists of an interactive application about dividing by 8. Students form a maximum five digit number by selecting the digits. Then they try to find the digit or digits with drag-drop operation on the shapes numbered as (0,…, 9).

The application sessions went well. Students really liked the colorful activities and were able to visualize concepts in different ways. They sometimes used the LO on computers, in pairs or individually. Students both interacted with LOs, with each other and also with the teacher.

One of the LOs (11. Equivalence Classes) used in the application session is depicted below;

This LO consists of an activity which has different cases of operations in Z/1,…, Z8. As seen in the Fig. 5; (3–0, 2–2, 0–3…)/Z5, some random selected operations' results are given by the object. The other operations are filled by students.

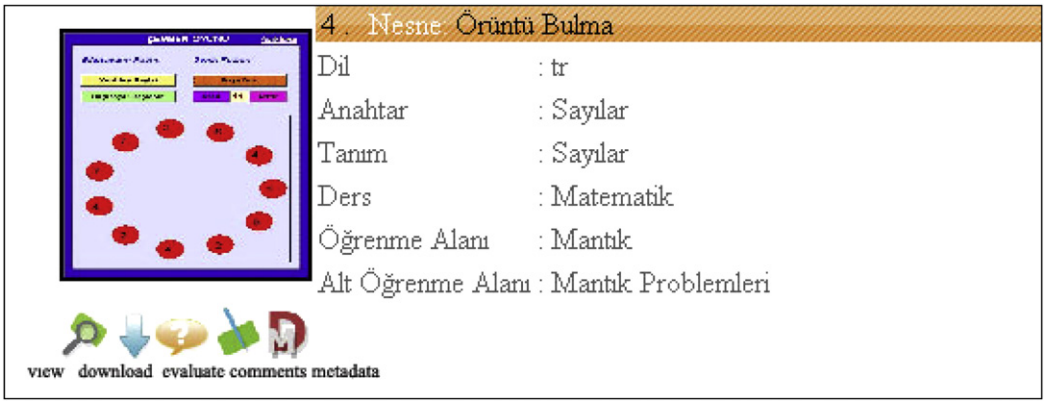

Fig. 3. Learning objects in LOR.

Table 1
LOs use schedule.

Distribution of LOs to the weeks			
Date	LO header	Brief explanation	Duration
1st week	1. Natural numbers 2. Number puzzle	Operations about natural numbers A puzzle consisting different types of numbers	2 h
2nd week	3. Eratostenes 4. Prime numbers 5. Prime factors	An activity consisting the ways of finding primes by method of Eratosthenes A drill and practice application about finding primes An application for finding prime factors of given numbers by a factors list.	2 h
3rd week	6. Priority of processing 7. How many rational numbers are there?		2 h
4th week	8. Examining operators 9. Integers 10. The minimum edged square	A drill and practice activity about examining the effect of operators when changing the order and the effect of parenthesis. The different characteristics of integers and divisibility An interactive rectangle forming minimum edged squares for gcd and lcm	2 h
5th week	11. Equivalence classes 12. Modular arithmetic in cryptography	A drill and practice application about operations in Z/m A game about encrypting the letters by using modular arithmetic.	2 h
6th week	13. Addition in rational numbers 14. Subtraction in rational numbers	Addition with interactive fractions in the form of circles, rectangles, triangles, etc. Subtraction with interactive fractions in the form of circles, rectangles, triangles, etc.	2 h
7th week	15. Exponents and square roots	Finding exponents and square roots on an interactive grid.	2 h

This object is used by the teacher when teacher is teaching the objective from the curriculum such as; "Presents the characteristics of equivalence classes" and "Does addition and multiplication operations in Z/m set." Considering that some students learnt something about these objectives in the previous year, in order to explain the subject again, the teacher prepared some examples on the LO before coming to the classroom.

The teacher has started lesson by writing $(3 + 5 = ?)$ in Z/7 on the board. No one could answer it. Some of them had learnt what Z/m means before but they had never done operations on Z/m. The teacher showed them how to do operations by a simple example about addition on the LO. By doing examples students have seen that the object has some random results. The mistaken cells are red in color and the correct cells are blue.

First, the teacher wanted the students to study on Z/3 addition operation. One of the students met a case of $2 + 1 = ?$ And he answered it as 3 in Z/3. Hence, the object gave feedbacks to him. The screenshot from this operation can be seen in Fig. 6.

After completing Z/3, all students understood the rules for operations in Z/m. Then the teacher wanted them to make the other operations. They all selected different cases, and different operations. The different types of Z/m (m:1…8), the different types of four operations and the random resulted cases made the object reusable which is one of the main characteristics of LOs. Thus, this reusability is welcomed by the teacher. These characteristics are also seen in 2nd example of Fig. 6.

A small passage is extracted from the student–teacher dialog while students (S1, S2) are studying on Fig. 6, second example.

S1: I met an interesting case. The whole rows have the same numbers but only the cells of the numbers are changing. For example, the second row has 0,1,2,3,4,5 and the third one has 0,2,4,6,3,4.
Teacher: What does this tell you?
S1: I think this is because we can use maximum 6 in Z/7.
S2: I think so, as the previous example in Z/3 2 + 2 is not 4. It must be 1. This is the same case.

Then the teacher wanted all the students to do all addition, subtraction and multiplication activities and encouraged them to get the best marks. Because LO has marks for students scores.

At the end, she asked a question $(4 + 5) \times (3 \times 2) = ?$ in Z/6 in order to see that if students could use the object in different ways. Many of the students opened the object in two different windows, and calculated the two parentheses. By this way they had experiences about the flexible use of LOs.

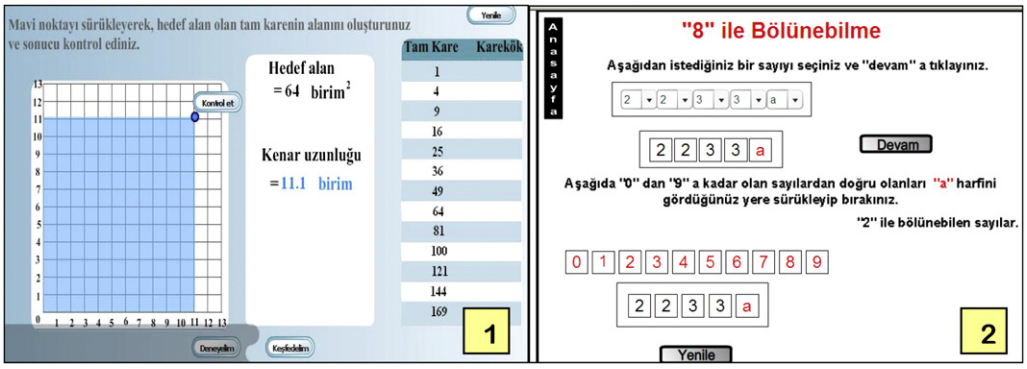

Fig. 4. Screenshots from two LOs used in applications.

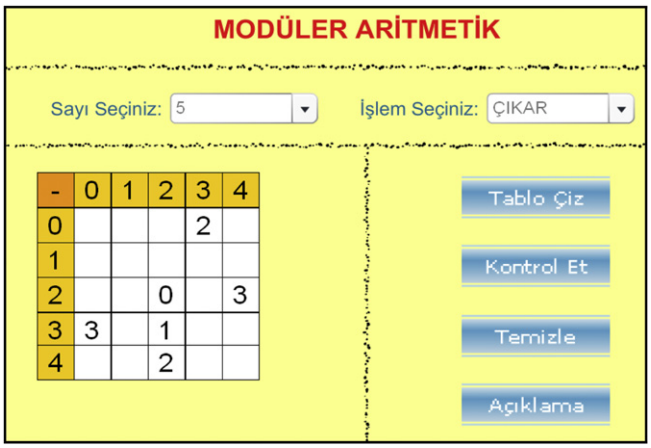

Fig. 5. An example LO used in mathematics classroom (Equivalence Classes).

The other LOs also had similar characteristics. Students generally met different cases on Los. Then, they tried to understand and solve the problems or complete the activities on LOs. While studying objects, students endeavored on LOs on their own or sometimes they interacted with other students. In this period, they had some changes on their cognitive structures. This working period on LOs generally referring Piaget's extensive work with children revealed many insights into students' move through development. Sometimes the "disequilibrium" concept of Piaget may come up when the experience of a child resulting in some subjects is new and unexpected. The child may experience this as confusion or frustration. Sometimes the child's interaction with the learning environment may help him to assimilate the experience. Then this help the child change his cognitive structures to accommodate which is defined completing the cognitive adaptation (Baki, 2002).

4. Methodology

The sample of this study was 30 students at grade 9th. The study was conducted in a high school in Trabzon, Turkey. Both quantitative and qualitative data was gathered in order to answer the research questions. One of the quantitative data resource was LOEF (Learning Object Evaluation Form) (Schoner et al. (2005)) which was applied on students to observe how the students evaluated the use of LOs. The form includes the items under the sub-sections as LO's Learning Value, Value Added by LO, Usability of the Design and Technology Function. The students used this form in the web environment and filled the form three times (1: after 2nd week, 2: after 4th week and 3: after 7th week) and evaluated the objects according to items on it. Another quantitative data resource was Internet records. Internet records which held working time period and the frequency of study with an object during study were used for obtaining statistical data about how students used the LOR. Descriptive statistics were used for all quantitative data. The qualitative data was gathered from interviews conducted with students and the teacher. Students' opinions and approaches towards LOs were held concerning the interviews conducted with 6 students within the study group. The students were selected by their previous year academical achievements in mathematics course. The distribution of 6 students was equal; the two of them were "good", two of them were "average" and the others were "below the average". The interviews were usually in a one to one setting, with each participant having two separate interviews; first was at 4th week, and the second was at the end of the application. The opinions of the interviewees were recorded during the talks with a tape recorder.

The views and attitudes of the students were analyzed by categorizing them as themes. In order to identify salient themes, the researchers used codes and frames to analyze the data individually. Then, the comparison of their analysis on similarities and differences put

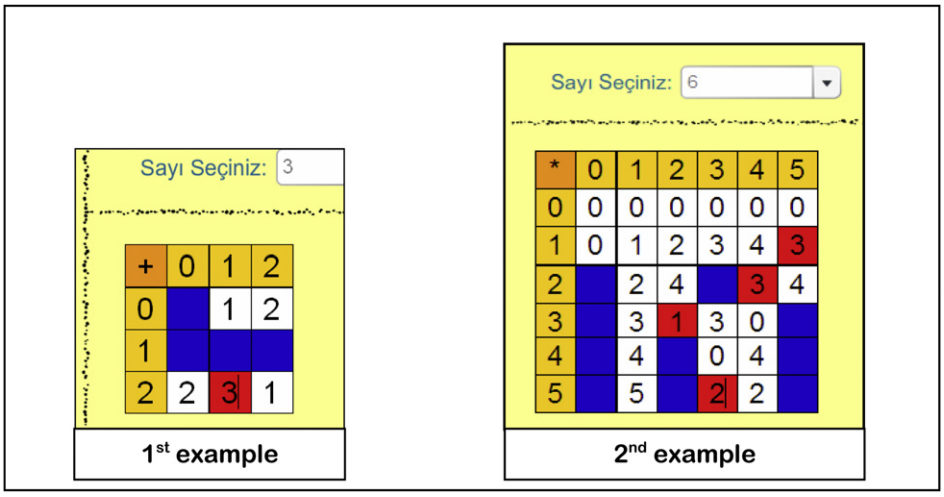

Fig. 6. Two different cases on the selected LO.

forward the mutually agreed themes. Once a set of coding themes was developed and defined, they were then tested to see if coders used the same definitions. If there was little agreement on the number of responses that fell into a given category, the definition of that theme was discussed, and possibly revised.

Also, the data from these interviews were compared with the data received from observations made by the researchers. In order to understand the reasons why teacher preferred LOs and the aims for using them, the views of teacher were obtained at semi-structured interviews within certain time intervals. The qualitative data obtained from the teacher was categorized and presented according to frequency of usage.

5. Findings

The findings of the study were presented with four different sub titles according to the research questions.

5.1. How did the students use the LOR?

The students" styles of using the learning object repository were automatically saved by the system into database as working duration and frequency of study with an object. When studying period was determined, if there appeared no motion on computer in a definite interval time, it was decided not to evaluate this time because it was considered that the student has gave up studying with that object. When the object was opened within a little definite time but with long intervals, it was considered that the frequency of object usage increased and it was taken into consideration. Hence, by this way the records were acquired concerning the usage of the system and frequency of usage by students on objects both in the class and out of the class and it has been revealed the profiles of usage of objects as in Fig. 7 were revealed.

5.2. How did the students evaluate the use of LOs?

In this study, the answers given by students to the evaluation form were analyzed through descriptive statistical techniques. As the findings acquired from the evaluation forms filled by students during 7 weeks were analyzed under the titles, the results were shown in descriptive form in Table 2. The evaluation criteria are divided into sub-sections which are:

Learning Value: Includes items that how effectively the LO helped them learn or understand the subject.

Value Added by LO: Reflects evaluations of comparisons about LOs which had advantages over other learning materials or methods.

Usability of the Design: Students' perceptions of the ease and clarity with which they were able to follow the instructions and follow the activity on LO.

Technology Function: Evaluations of students how suitable the object functioned technically.

The titles have the averages up to 5 as; Learning Value (3.79), Value Added by LO (3.59), Usability of the Design (3.65) and Technology Function (3.06). The results from students' evaluation form in percentage of total responses per sub-sections may be summarized as below.

In the "Learning Value" sub-section; the 4 (Agree) and 5 (Strongly Agree) were responded 64.6% totally in both of the items. Similarly, 57.7% of possible responses within the "Value Added by LO" sub-section were in the Agree and Strongly Agree categories. Only the item "I was able to study the examples in a way that would not have been possible by attending a lecture or reading from books." has more negative response frequencies ($n = 8$) than the other items. In "Usability and Design" sub-sections; the positive (Strongly Agree and Agree) options have average percentage 54.15% for all items. All of the items have less frequency of negative responses (Strongly disagree or Disagree) in these sub-sections. In "Technology Function"; all items are negative in meaning so the items are marked (1: Strongly Agree,…, 5: Strongly Disagree). In this section the frequencies of positive and negative responses are nearly equal. Only the first item "I was not disadvantaged because I possess adequate computer skills." has more positive responses than the negative ones.

The frequencies of the options marked for every item in the evaluation form were determined according to the following scale by the average of the items of each sub-section. (1.00–1.79:not sufficient, 1.80–2.59: merely sufficient, 2.60–3.39: sufficient, 3.40–4.19: highly sufficient, 4.20–5.00:excellent).

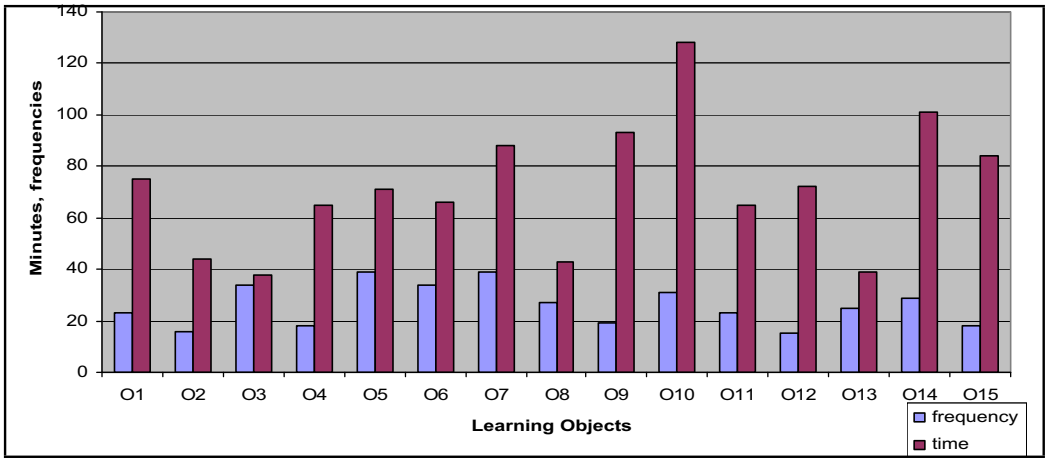

Fig. 7. Average usage time and average frequencies of LOs by the students.

Table 2
Students' evaluations about LOs.

Evaluation Criteria	$\overline{X_1}$	$\overline{X_2}$	$\overline{X_3}$	$\overline{X_E}$	Sd	Strongly Agree		Agree		Neutral		Disagree		Strongly disagree	
						5		4		3		2		1	
						f	%	*f*	%	*f*	%	*f*	%	*f*	%
Learning value															
I could learn on my own speed.	4	4	3.6	3.87	1041	9	30	13	43.3	3	10	5	16.7	0	0
It provided to learn without using any notes.	3.9	4	3.8	3.9	1155	12	40	8	26.7	6	20	3	10	1	3.3
It provided to visualize the topics.	3.7	3.9	3.8	3.8	0.886	7	23.3	12	40	9	30	2	6.67	0	0
It made easy to understand subject matter.	3.5	3.8	3.8	3.7	0.987	7	23.3	11	36.7	8	26.7	4	13.3	0	0
I learnt better the course topics studied before	3.6	3.8	3.6	3.67	0.994	8	26.7	7	23.3	12	40	3	10	0	0
Value added by LO															
I could solve the problems easily with these LOs.	3.6	3.6	3.5	3.57	1194	7	23.3	11	36.7	6	20	4	13.3	2	6.6
I experienced by solving a lot of problems that otherwise I wouldn't have done.	3.5	3.6	3.7	3.6	1248	8	26.7	10	33.3	7	23.3	2	6.67	3	10
I was able to study with examples in a way that would not have been possible by attending a lecture or reading from books.	3.3	3.9	3.6	3.6	1221	10	33.3	6	20	6	20	8	26.7	0	0
Usability of the design															
The site can be easily understood and used.	3.3	3.7	3.5	3.5	1253	8	26.7	7	23.3	10	33.3	2	6.67	3	10
The concepts and efficiencies presented in learning environment have been presented briefly and it is easy to pursue.	3.7	3.6	3.9	3.73	1048	9	30	7	23.3	12	40	1	3.33	1	3.3
The segments of the website are in a logical order.	3.6	3.8	3.7	3.7	1022	8	26.7	9	30	9	30	4	13.3	0	0
The defined comments provided to complete the activity on efficiencies.	3.7	3.7	3.6	3.67	1470	14	46.7	3	10	5	16.7	5	16.7	3	10
Technology function															
I was not disadvantaged because I possess adequate computer skills.	3.1	3.6	3.3	3.33	1397	8	26.7	7	23.3	6	20	5	16.7	4	13.3
I couldn't attain the information because of technical problems.	2.8	3.4	3.1	3.1	1195	4	13.3	5	16.7	15	50	2	6.67	4	13.3
I couldn't use the environment because of the technical difficulties.	2.6	3.1	3	2.9	1322	4	13.3	6	20	9	30	5	16.7	6	20
I couldn't use the system owing to other reasons.	2.9	3	2.8	2.9	1583	7	23.3	5	16.7	5	16.7	4	13.3	9	30

$\overline{X_1}$: 1st evaluation average

5.3. What were students' attitudes and views towards LOR?

In the interviews; the students were asked to introduce their experiences with LOs throughout the study as liked and disliked cases. They were asked to refer to LOs as being or not being engaging, enjoyable or interesting. They compared their lessons with LOs to their previous lessons without LOs. They also specified their preferences for using LOs.

Generally most of the students were pleased to study with learning object repository. They found it interesting and enthusiastic. It was seen that they could design the activities on their own, and create their own problems and solve and take the learning responsibility.

Additionally, in accordance with the given answers, LOs colud be used with the aim of doing exercise and studying the subject again when it was not understood. As indicated in the students' evaluations of LOs in Table 2, students generally had positive views in the interview. Moreover, students had a few negative views about the LO based learning environment.

Some of the extracts chosen from interviews which reflect the most common views include both positive and negative views have been stated below:

- *What were the liked and disliked cases while studying with learning objects?*

" It is like playing a game. In fact, it is nice to feel that you are not in a course. You can control yourself, and sometimes compete with yourself and each object has different characteristics in itself."
"There are no undesired cases but sometimes small technical problems have occurred. In addition, the object parameters in a few casesdo not give the expected results."
"In some lessons teacher helped us. However, all objects were attractive; we studied as if we are playing a game during the lessons. But sometimes it was difficult to do calculations on the computer."
"Some objects include similar questions so why should I complete them all. Sometimes I think I am wasting time to complete the whole activities on objects.""
"I studied the way I wanted on the most objects. Sometimes it was a good idea being alone without tthe teacher"

- *Do you think that you benefited from learning objects?*

"Certainly, I used them both at school and at home. I understood the subjects better. At the beginning of the term, I had difficulty in understanding LOs, but day by day, I adopted using LOs.I sometimes saw my own mistakes without any help from the teacher."
"I understood the subjects which I hadn't understood before. I realized that I enhanced my mathematical understanding."

Table 3
The sub-section average percentages of students' evaluation.

Sub-section ($n = 30$)	Strongly agree%	Agree%	Neutral%	Disagree%	Strongly disagree%
Learning value	28.6	34	25.4	11.34	0.8
Value added by LO	27.7	30	21.1	15.5	5.53
Usability and design	32.5	21.65	30	10	5.82
Technology function	19.15	19.17	29.17	13.34	19.15

"*Before this application, I was not interested in mathematics. Generally I didn't want to study more. But with these activities, I realized I could achieve something, too. I felt I could both answer the questions and have abilities to solve problems".*

- *What was your aim in using the objects and why did you prefer to use them?*

"*I did exercises and sometimes studied the examples which the teacher gave as a task.*
"*I also used them easily for performing mathematical problems. Sometimes I reviewed the subjects by using objects and sometimes I learnt concepts which I couldn't understand before. Hence, the aims of using LOs depended on the features of objects which I used."*
"*The animations and graphics on LOs helped me to understand the subject and also it was enjoyable to change parameters or using the objects with the mouse movements such as drag-drop operations.*

- *What kind of differences did you address between the previous mathematics lessons and the lessons with objects?*

"*Here you are alone with the computer. When you have a mistake on objects, it gives error messages, so you can create your own questions and solve them. You can also ignore the question which you got difficulty in solving. You can try it later".*
"*I needed the help of the teacher only a few times. Objects told me what I had to do, so I was independent from the teacher generally…"*
"*I think all the courses should be in this format. I didn't know why I should learn some subjects. I related the concepts to daily life examples thanks to the LOs. I think it was the main benefit for me.*
"*I will refer to these objects when it is necessary".*
"*I met an unexpected result for one time, so I couldn't calculate the exponent."*
"*The activities were good, but can I solve the problems in the exam?"*

The views and comments of the students are coded and the main themes are defined due to the descriptive analysis results presented below: (Table 4)

5.4. How and for what purpose should the teacher use LOs?

The system records have been examined for the purpose of determining the aims of teachers for using them and the reasons for preferring them, and the interviews below have been conducted at the end of 3rd and 6th weeks concerning with LOs that the teacher has applied in the courses.

- *When you consider the appearance of objects, which characteristics did you pay attention while choosing the objects related with the design? Which characteristics did you take into account while choosing the objects? What were your reasons for choosing these characteristics?*

"*First of all it is important to have an interesting view for students. Even the view of the object icon is important. I prefer to use the pages which have suitable color and are full of pages. I mean, the pages do not have many blanks in the page. I think students will enjoy them more. When I use the objects solely or use them by combining some of them, the colors of the pages should be consistent and there must be integrity on the page. The shapes, figures and the drawings on the objects are also important. Sometimes the audio and the speech on the object make it preferable for me. Of course, I took care of the quick loading of the object."*

Table 4
Students' views about LOs.

	Themes about students' views	Sample statements most used	1. Interview		2. Interview	
			f	%	*f*	%
Positive Views	Not getting bored	I didn't feel bored working with LOs.	5	83.3	6	100
	Enjoy	I was pleased with working LO based learning environment.	4	66.6	5	83.3
	Interest	I was interested in activities on LOs.	5	83.3	5	83.3
	Motivation	I found the LOs motivating	3	50	4	66.6
	Study	I have begun to study more by this application.	4	66.6	4	66.6
	Like overall	I liked the idea of using LOs for learning	6	100	5	83.3
	Future use	I would like to use these LOs again	4	66.6	3	50
	Help learning	I believe LOs make it easier to learn the content.	3	50	4	66.6
	Responsibility	I could take responsibility for my own learning	2	33.3	1	16.6
Negative Views	Similar activities	There were some similar activities and a few unexpected results.	2	33.3	2	33.3
	Getting tired	I was tired of and fed up with studying LOs.	2	33.3	3	50
	Exams	I worried about exams.	1	16.6	2	33.3

Table 5
The teacher's objectives about using objects.

Main objectives about using LOs	The details of the objectives (teacher statements)	The frequency of LOs which the statement is used for		The total frequency and percentage	
		1st interview	2nd interview	Total	
		f	*f*	*f*	%
Design based reasons	Since the appearance of the object is nice	7	5	12	80
	To provide the color harmony	5	4	9	75
	To emphasize the related section	4	3	7	46.7
	Since the size of object is small	1	2	3	20
	To provide the integrity on the page	4	5	9	75
Student based reasons	Its suitability for students' level	5	3	8	53.3
	To enable the interaction between student and computer	3	4	7	46.7
	To enable motivation	5	4	9	75
Content based reasons	For asking questions	3	5	8	53.3
	To enable the course order	4	5	9	75
	For strengthen the course	4	4	9	75

- *If you consider your students' position, their interest in objects and the cases such as their interaction with objects, what are the points that make you consider choosing the objects related with your students? Which characteristics of the learning objects do you consider to choose related to students? Please define the reasons for choosing them.*

" *First of all, the students' position level is an important factor. The activities on the objects should be completed and should be enjoyable. Additionaly, I think students can learn with the simulations and games, so I choose these kinds of objects. Students should interact with the activities on the object and should use them easily. The objects should be comfortable for students.*"

- *About the course processing and the duration of the course design, what kind of factors have you been influenced while choosing LOs. Which factors in which objects did you consider in that process? Please state why you chose these characteristics? Please state the reasons (if yes) of using objects except for these?*

"The continuity of the subject is also important. For the transition from subject to another, the best LO should be selected. If I use the object at the beginning of the course, sometimes it may be time-consuming, so I choose the objects according to the sequence of the subjects. I considered the duration of activities on objects. If I began to use the time-consuming LOs, the course would be so long, so I tried to use the short object that had the same objectives. I look at my plan and if I need to ask questions and use drill and practice method, I tried to do these on the object. For example, in natural numbers course, I used the questions like "ABC + BCA = CBA" from the object, I didn't prepare any other questions. Anyway the object had many examples like that."

The teacher explained the reasons why she preferred using every object in accordance with the questions asked to her for the application in which totally 15 LOs were used. The answers stated by the teacher have been presented in the table below with codes. (Table 5)

The frequencies of the statements given by the teacher in the interviews are considered as the data for the teacher's objectives about using LOs and reasons of preferring them. After coding process, the objectives of teacher categorized into three main themes as design based, student based and content based objectives. The details of main themes which are named as "the details of the objectives (teacher statements)" in Table 3 are also extracted by the researchers after investigating teacher's statements in detail. When two interviews have been observed, it is seen that the 12 objects of 15 have been mostly preferred owing to their nice appearance (80%). In addition to the items related with design such as color and integrity, the content based reasons such as student's motivation (75%), enabling the course order (75%), and strengthening the course (75%) are among the reasons why these objects are mostly preferred. On the other hand, the size of the object is only stated for 3 different objects of 15 which have (%20) percentage. Hence, the size of the object was not an important reason for preferring the objects. Overall, the teacher reported that the LOs as beneficial for students, and they helped students with their learning process and also added that she would use them in the future.

6. Conclusion

The findings of this study highlight some important issues for using LOs in mathematics classrooms. The results are discussed in the sections of "Use of LOs", "Students' Views", "Teacher Perspective" and "Students' LO evaluation".

6.1. Use of LOs

Internet records are used in order to reveal the usage rates of each LO. Internet records illustrated that the students used 15 LOs totally in 1072 min. This total time refers to the sum of average usage period of each LO $t = (\overline{t_1} + \overline{t_2} + \overline{t_3} + \ldots \overline{t_{15}})$. The average time period is found as 71.46 min for all LOs which is found by dividing the total time period by 15 $(\overline{t} = (\overline{t_1} + \overline{t_2} + \overline{t_3} + \ldots \overline{t_{15}}))/15$. In addition, each LO had an average of 26 times usage rate. This average time period is found by dividing sum of the usage rates of each LO by 15. The reasons for this usage rate are that the students need to review the objects they have used before, or they sometimes would like to try the content of the activities they have been engaged or they try to review the activities they couldn't complete before.

6.2. Students' views

The students' views and approaches about the used objects have indicated that the innovations in courses by using LOs have influenced themselves in a positive way. Students have made positive comments about the motivational and learning themes. For instance, they said that LOs were not boring, they enjoyed them and they were interesting and motivating. They also added that they were pleased with their overall performance; they helped them study and learn more and encouraged them to take more responsibility in their learning process. Students liked the LOs which had enhanced interactivity and higher visual potentials. Students' statements on the usage of LOs implied that LOs supported individual learning as scaffolding. Being in a learning environment under the control of themselves with the usage of LOs has increased their interest in the course. Means such as games or competitions which are two important factors in LOs have enabled to create an interesting learning environment for students. The observations in the lab showed that the LOs which the teacher helped students to use or to complete the activities have been used for a longer time than the others. The LOs used independently from the teacher have been repeated more frequently than the others. Only a few students stated negative views about the LOs based environment. The negative views were generally about similar examples, such as getting tired and worrying about exams. By focusing on the observations of the participants in the course, the reason for getting tired may depend on the deficiencies in computer literacy of students or technical problems which appeared occasionally in computer lab. Results indicate that there might be some problems for students while studying with the LO, such as technological conditions and time-consuming. Hence, generally there were minimal technical problems that occurred during the study and these problems may cause a few students to give negative responses. However in general, these technical features did not appear to be serious impediments.

In addition, as the teacher mentions the inadequacy in explanation of the objects or some calculation difficulties on some objects, they might cause these negative thoughts. Another issue about negative views was similar examples. In order to enhance the reusability features of LOs; they were programmed to construct various cases, so when the student tried many cases, they met some similar examples, as sometimes the only difference between the cases colud be the parameters. And a few number of students were worried about relating the exams with the LOs.

The findings about the attitudes of students are parallel to the results of research studies participants' attitudes revealed that there was a generalized feeling among the participants in regarding the importance of learning mathematics and its significance in daily life activities (Lopez-Morteo & Lopez, 2007).

6.3. Students' LO evaluation

Students have evaluated the LOR as highly sufficient in terms of Learning Value (3.79), Value Added by LO (3.59), Usability of the Design (3.65), and they have evaluated Technology Function as sufficient (3.06). Hence, only the Technology Function sub-section is responded as "Sufficient" and the other sub-sections are all responded as "Highly Sufficient". Thus, the findings indicate that 15 objects used in 7 weeks time are convenient for students in terms of learning, usage and technological consistency. With respect to the other features the Learning Value that an LO offers is rated the average highest points. The Value Added by LO and the Usability of the Design is lower than the Learning Value category. Even though the average values of the categories are nearly equal, this result has some contrasts with other LO evaluation studies in which the learning value of LOs is not the highest issue (Kay & Knaack, 2007; Krauss & Ally, 2005). The results of evaluation and the students' views show that LOs provide a good experience for students and the teacher.

6.4. Teacher's perspective

The teacher sometimes designed lessons around one or two objects and generated complementary lessons with the objects. Sometimes she let them free to study with LOs by themselves. Teacher's perspective about preference for using LOs appeared to include three main themes as "content, design and student". For the teacher, LOs provide interesting scenarios and problems helping to comprehend the concepts related to the subject. In addition, the objects are generally preferred by the teacher owing to the nice appearance of the objects and motivational effect. The teacher mentions that LOs with their design features can be used to construct rich learning environments with their rich activities. Brown and Voltz (2005) define the rich activities for action rather than directing students down in a prescribed way. Hence, the rich activity will have an interesting structure which will provide students with an extensive use of humors and imaginations. Therefore, in the study of McCormick and Li (2005), teachers considered that LOs were beneficial tools for learning, and they could be used for scaffolding to understand concepts. Besides, they were interested in using LOs in their classrooms. The teacher in this study also had the similar thoughts after the application.

The preferences about teacher's LOs use are consistent with the result of a case study research about LOs use in classroom environments (Ilomäki, Lakkala, & Paavola, 2006). The preferences are shaped through student, design and content based causes. The result about preferences indicates that organizing, structuring and guiding processes of the course are crucial.

In conclusion, as Kay and Knaack (2007) pointed out that, students may benefit from LOs; if they are comfortable with LO offering good learning control, useful content and clear instructions. Most of the students in our study generally had positive views about an LO based learning environment. As we observed during the study, the teacher tried to use LOs as an instructional tool in her lessons and guide students' work in such an environment. This implies that the teacher also found LOs valuable for teaching and learning mathematics. LOs as teaching and learning tools have appeared to be useful in high school mathematics classrooms.

As seen in this study, it is possible that LOs may be used in the classroom. Making the usage of LOs common can be possible by preparing high quality LORs and training teachers who are going to use them. As well as making various researches on that issue, it is necessary to make LOs common and provide the teachers both in-service and pre-service training. In parallel with this, decreasing the deficiencies in computer literacy will help them to benefit from the opportunities of the new technologies. Technological skills are a valuable way to shape the classrooms by giving opportunities to students and preparing them for today's learning environments. Therefore, it is necessary that the teacher should be the guide in this respect.

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